Spectral Solar Radiation Intensity in Two Florida Forests

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Photochemical reactions in plants are dependent upon minimal energy levels of several wavelengths of light. Therefore, a knowledge of the spectral intensity of radiation within plant communities is of some importance in explaining the presence or absence of some species, as well as in determining the efficiency of basic processes such as photosynthesis.

Most data on the spectral intensity of light in forests have been obtained using filters, much of which has been summarized by Anderson (1964). Robertson (1966) worked with five filters in the range of 366 to 740 nm in four crops and a hardwood forest near Ottawa. Vézina and Boulter (1966) used five filters (344-737 nm) in measuring light transmission in a pine stand and a maple stand.

The development of new instrumentation in the early 1960's made it possible to measure the continuous spectral distribution of visible and near-infrared solar radiation. Yocum et al. (1962) and Lemon (1962) reported the first complete (300-1000 nm) spectral distribution curve, obtained in a corn field. Their work was later published in more detail (Yocum et al., 1964). Tanner (1963) published transmission curves of shortwave radiation (400-740 nm) in a pine stand and a red maple stand. This work was extended and much additional data reported by Federer and Tanner (1966), including transmission curves in several hardwood and conifer stands. Freyman (1968) used an ISCO spectroradiometer to record the spectral distribution (400-750 nm) of light in fir, lodgepole pine, and aspen stands.

No work has previously been reported on the spectral distribution of shortwave radiation in forests of the southeastern U. S., and only Yocum et al (1964) extended their measurements to 1000 nm.

Two common North Florida community types were selected for this study, mesic hammock and sandhill. Both stands are located in the San Felasco Hammock, northwest of Gainesville.

Monk (1960) compared the vegetation and soils of the same two stands in which this work was done. He found that the number of tree species (22 vs. 2) and basal area (46.2 vs. 14.4 m^2/ha) were greater in the mesic hammock than in the sandhill, while the sandhill had more unoccupied space in the shrub, understorey, and canopy layers. The mesic hammock is a fairly complex, stable community, located on moderately fertile, moist soil. It contains a large number of species, many of which are evergreen. The sandhill community, on the other hand, is relatively simple, dependent upon fire, located on infertile, xeric soils, and is comprised of few species.

METHODS

An ISCO model SR spectroradiometer, in conjunction with an ISCO model SRR programmed scanning recorder, was used for all measurements. The instrument provides a continuous wavelength scan from 380-1050 nm; it has a half-bandwidth of approximately 15 nm in the 380-750 nm range and 30 nm in those wavelengths longer than 750 nm. Because of the inconsistency of the response of the photocell to wavelengths shorter than 425 nm, all data for wavelengths in the 380-420 nm range were discarded. The radiometer was calibrated using an ISCO SRC spectroradiometer calibrator, which provides constant voltage at adjustable current to a ribbon filament lamp of known spectral emission.

Four points were randomly selected in each of the two communities. Control readings, to determine incident radiation, were taken near the center of a forty acre clearing located 1.1 miles east of San Felasco Hammock. All readings were taken between 9:00 AM and 1:30 PM on April 6, and the sky was cloudless during the time that data were recorded. The sequence of measurement was as follows: clearing; mesic hammock (2 points); sandhill (2 points); clearing; sandhill (2 points); mesic hammock (2 points); clearing. A minimum of three and a maximum of six complete spectral scans were recorded at each point per setup. The radiometer was placed on the ground, with care taken to assure that the diffusing head was horizontal. The sensing element was 32 cm above the surface. S. C. Snedaker aided in taking the field measurements.

In order to adjust for the varying half-bandwidth of the instrument, a wavelength interval of 25 nm was used to obtain data from 425-750 nm, and one of 50 nm for 750-1100 nm. After calculating the mean intensity at each wavelength at each point, radiation intensity (microwatts $cm^{-2}nm^{-1}$) was plotted over time for each site. The spectral intensity was determined by integrating each curve over time, and dividing the result by the time difference between the first and last measurement at each site. Since Gainesville, at 82°20′ west longitude, lies 7°20′ west of its nearest standard meridian, the mean hour of measurement was converted to True Solar Time (TST) according to the method described by Reifsnyder and Lull (1965). The resulting adjusted mean hour of reading was 10:30 AM TST.

RESULTS

The standardized spectral intensity of the radiation measured at each of the three sites is shown in Fig. 1. Because of the mag-

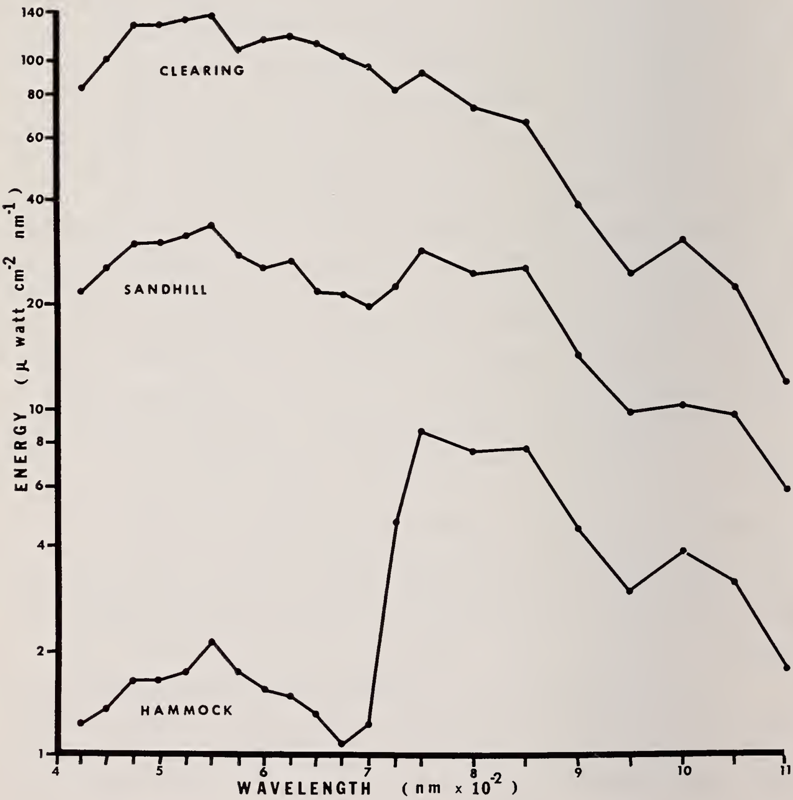

Fig. 1. Spectral intensity at three sites. Values standardized to 10:30 A.M. TST, April 6.

nitudes of the differences among the three locations, a logarithmic scale has been used on the ordinate. Energy levels in the clearing reach a maximum of about 134 microwatts $cm^{-2}nm^{-1}$ at 550 nm, then gradually taper off to approximately 12 microwatts $cm^{-2}nm^{-1}$ at 1100 nm, the longest wavelength considered. The clearing curve is similar in form and magnitude to those reported by Gates (1966). The curves for the two communities are much reduced in magnitude, yet similar qualitatively to the clearing curve, except from 600 to 725 nm, where both communities transmit proportionally less of the incident radiation.

In Fig. 2, the spectral intensity of radiation within each of the

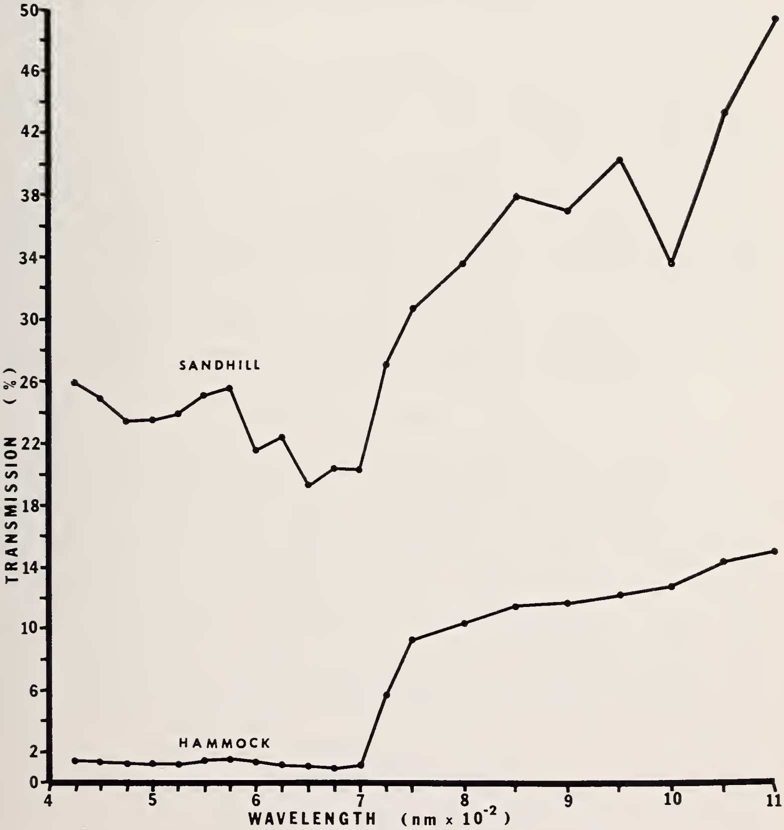

Fig. 2. Spectral distribution of transmitted shortwave radiation in the two plant communities, expressed as per cent of incident radiation upon the clearing.

communities is expressed as a percentage of the incident radiation. In the visible range, only 1.33 per cent of the incident radiation is transmitted in the hammock, as opposed to 22.96 per cent in the sandhill, a 17-fold difference. In the near-infrared, however, the difference is not as great; the hammock transmits 11.42 per cent and the sandhill transmits 36.91 per cent.

The distribution of radiation in the two communities is summarized in Table 1, where the data are expressed as fractions of total incoming shortwave radiation in the range of 425-1100 nm. The smallest component is the transmitted visible light in the mesic hammock, which constitutes only 0.8 per cent of the total incoming shortwave radiation. This is less than 1/16 of the corresponding fraction in the sandhill.

TABLE 1

Fractional distribution of total shortwave radiation (nm) in sandhill and mesic hammock communities

	Hammock			Sandhill		
		Visible	Near IR		Visible	Near IR
Disposition	Total	425-700	725-1100	Total	425-700	725-1100
Transmitted	.046	.008	.038	.272	.148	.124
Absorbed and Reflected	.954	.636	.318	.728	.496	.232
Total	1.000	.644	.356	1.000	.644	.356

DISCUSSION

The shape of the transmission curves for the two communities is similar to those of Yocum et al. (1964) in corn, Federer and Tanner (1966) in several hardwood and conifer stands, and Freyman (1968) in two conifer and one hardwood stand. The sandhill community shows a rather irregular transmission in the visible range with no marked depressions, which is very similar to the results obtained by Vézina and Boulter (1966) in a red pine stand. They attributed this neutral filtering to the fact that they were working in a coniferous forest, but my results suggest that neutral filtering may be characteristic of other monospecific vegetation types, hardwood or conifer; in this case, the species is turkey oak (*Quercus laevis*). This observation is further confirmed by the data of Yocum et al. (1964) and Federer and Tanner (1966).

The mesic hammock demonstrates a definite absorption and/or reflection maximum of 675 nm, which is within a half-bandwidth of one of the chlorophyll absorption peaks. This indicates that the mesic hammock is more successful than the sandhill in absorbing photosynthetically useful wavelengths.

Both communities transmit a relatively high proportion of the incident near-infrared radiation, similar to the results reported in corn by Yocum et al. (1964). The per cent transmission curve for the sandhill indicates a definite decline in transmission at 1000 nm. The data on leaf absorption and reflection of Yocum et al. (1964) lead me to believe that this decline represents an increase in reflection, rather than increased absorption. If this is the case, it might be one mechanism by which turkey oak reduces its uptake of heat-producing radiation.

Transmission of visible radiation by most forests ranges between 7 and 15 per cent (Reifsynder and Lull, 1965). The 23 per cent transmission by the sandhill community is exceptionally high, but not surprising when one considers that most measurements have been made in dense forests with at least 80 per cent crown closure, whereas crown cover in the sandhill is only about 40 per cent (Monk, 1960). Furthermore, since the sensing head of the radiometer was located at 32 cm, absorption of radiation by the grass and herbaceous ground cover was not considered in the measurements. If the ground cover had been included, this high transmission would have undoubtedly been reduced considerably.

The transmission of only 1.3 per cent of the visible radiation in the mesic hammock is lower than any reported in the literature. Crown closure, however, is not significantly greater than that of other forest types which have been studied. One parameter that is different is the number of species present; no other type for which transmission data are available has as many as the 22 that are present in the hammock. If this does account for the increased absorption, it would indicate that the mesic hammock contains a series of species which are capable of utilizing solar energy at successively lowered intensities as radiation penetrates the stand.

Summary

The spectral distribution of transmitted shortwave radiation was measured in two North Florida communities. These data were compared with shortwave radiation incident upon a nearby clear-

ing. One community, a mesic hammock, has a complex structure, whereas the sandhill with which it was compared is a relatively simple community. Transmission for all wavelengths (425-1100 nm) averages about 4.6 per cent in the hammock and 27.2 per cent in the sandhill. The sandhill community acts almost like a neutral filter of shortwave radiation, whereas the hammock exhibits selectivity for wavelengths absorbed by chlorophyll.

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